University of Alberta

Factors Contributing to Frailty in the Oldest-Old

by

Merry-Jo D. Levers

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Canada

To Jacob

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Intro / Background

Perhaps the greatest health battle we face in the next 10 years as population aging occurs is frailty. Frailty is a multidimensional, complex syndrome that slowly erodes seniors' independence affecting individuals, families, and society. It has a slow, insidious onset often considered part of normal aging with outcomes that are an enormous cost to society. Frailty is most prevalent among the old, especially those who are 80 years of age or more[12, 18]. According to Statistics Canada, those who are 80 years of age and older are the fastest growing population segment[19]. From 1991 to 2001 this age group increased by 41%, and it is expected to increase another 43% in the next 10 years[10]. Unfortunately, seniors 80 years of age or older are often grouped and studied with other seniors over the age of 65, thereby ignoring the uniqueness of this group. Canada is facing a population explosion among this cohort as demographic shifts occur, and therefore it is likely that frailty will become increasingly common. The cost of frailty will affect the families of those who suffer from frailty, and the healthcare system as independence and health are slowly eroded. Those who are frail require assistance with Instrumental Activities of Daily Living (IADL) such as grocery shopping and banking, and basic Activities of Daily Living (ADL) such as bathing and dressing. The slow erosion of independence results in a loss of function required for daily living thereby creating an increased demand on family, friends, and the healthcare system to compensate. Frail seniors become increasingly dependent on family and friends, often leading to economic and caregiver burden[1, 42]. The impact on the healthcare system will demand the attention of policy makers and healthcare workers because of the increased consumption of monetary and human healthcare resources that accompanies frailty. Frail seniors are at an increased risk for morbidity, mortality, and institutionalization due to health complications and failing independence[35]. In addition, frail seniors are at risk for numerous health ailments and are highly dependent on the health care system due to multiple co-morbidities and functional decline. The costs of societal resources, including financial and human, contribute to the high price of healthcare and caregiver burden. Delaying the onset and progression of frailty will result in significant savings, both financial and emotional, for society. More importantly, delaying the onset will improve the quality of life for those who would have suffered from the earlier onset of frailty. Identification of factors that contribute to frailty among the Oldest-Old will help highlight where efforts would be most fruitful to prevent onset, or slow down the progression. It will assist policy makers to prepare for the future and healthcare workers to initiate effective prevention and rehabilitation. This study examined factors that contribute to frailty in the Oldest-Old using the framework developed by Brown, Renwick, and Raphael[6].

I. Purpose and Research Questions

The purpose of this study is to examine personal and environmental factors that contribute to frailty in the Oldest-Old.

1. What factors are identified in the theoretical and research literature as contributing to frailty?
2. Does the framework of Brown, Renwick, and Rapael[6] identify factors contributing to frailty (Appendix A)?

III. Literature

Frailty

There is little agreement in the literature, or among gerontological practitioners or researchers, regarding how frailty should be defined[24]. Some authors have focused solely on the physical aspect of frailty[26] while others have focused on strictly mental factors[29]. Some authors acknowledge the relationship between frailty and aging[41], while others argue that age is not a contributing factor[28]. Certain researchers are attempting to find serum markers that define frailty [25, 39], while other research groups argue that frailty is a social construct[6, 33]. Although this is not an inclusive list, frailty has been defined as a loss of physiological reserve[8], a diminished flow of energy between an individual and the environment[4], declining energetics and reserve[15], loss of adaptive capacity combined with a decline in functional independence[26], and reduced ability to carry out important social and practical activities[6,33]. Heterogeneity among definitions of frailty is as diverse as the seniors' population itself.

However, there are some common concepts in many of the definitions such as reserve capacity, an increased risk of loss, and the reversibility of frailty. The idea of reserve capacity is frequently mentioned and refers to resources available to accommodate change[5, 6, 9, 11, 26, 33, 34]. Both the resources and changes can be physical or social. For example, a physical change in a senior's world can be positively adapted to if they have social resources to assist with the change. A senior can be considered frail if resources are not available to adapt change. Another common thread is that frailty puts seniors at an increased risk for loss of independence[8, 9, 11, 12, 15, 23, 30, 33, 34, 38, 40]. Loss of independence results in an increased financial and social burden on the families, the healthcare system, and society in general. Finally, some of the authors/researchers agree that frailty is preventable and reversible[2, 7, 16]. Bortz[4, 5] summarized many of the theoretical underpinnings of frailty by defining frailty as a result of aging and the disuse of muscles. The effectiveness of muscle strengthening in elderly persons is well documented in the gerontological literature, and empirical studies support its preventative and rehabilitative effects for frail populations [7, 16, 32]. The notion that frailty is preventable and reversible has many implications for healthcare workers and policy makers in an era of population aging.

Oldest-Old

According to Health Canada[19], the Oldest-Old are the fastest growing population segment. It is estimated that by the year 2041, 4% of the population will be 80 years of age or older which translates into 1.6 million Canadians. Many aspects separate this age group from other people over the age of 65. These include activity limitations[3, 20], cognition status[37], health determinants[14], verbal intelligence and personality traits[13], and functional capacity[21]. Negative stereotypes of seniors abound in society, often a direct result of an unawareness of what is a 'normal' part of aging. Senility, isolation, depression and uselessness are misconceived to be inevitable in the later years of life[13]. These prevailing myths create stereotypes that the public and often seniors themselves start to accept as truth. Buying into these stereotypes causes a negative feedback cycle resulting in society and seniors expecting less and less from those who are aging. Attributing loss of function and independence to the process of aging creates a normalization of ailments that result from disuse and/or abuse, rather than aging. There are many studies directly challenging these aging stereotypes. Field and Gueldner[13] found that 44% of

seniors over 85 years of age maintained or increased intelligence level over the 13 years of study. Malbut, Dinan, and Young[27] found that women over the age of 80 could improve their aerobic and cardiovascular state by participating in an exercise program. These findings challenge the notion that dementia and disability are an inevitable part of aging. Nevertheless, a segment of the population does not experience complete health and independence as they age, but in reality are frail. The Oldest-Old constitute a large part of the frail population, and therefore it is important to study this cohort in isolation.

As the numbers of the Oldest-Old rapidly expand, the prevalence of frailty will likely escalate. This increase is not because frailty is a normal part of aging, but rather is more likely due to a proliferation in the occurrence and combination of varying contributing factors. Not all seniors experience 'good' health in their senior years, some instead experience an increased dependence on family, friend, and society. Increased dependence is largely attributable to frailty, and much of this increased dependence is preventable. In their very advanced years, most seniors initially begin to experience loss of independence in their IADL such as grocery shopping and banking, and progress to loss of ADL[30]. The factors contributing to loss of independence are both cognitive and physical. For example, Strain, Blandford, and St. John[37] found that only 38% of their study population over the age of 80 remained cognitively intact after 5 years had elapsed. In addition, even though Malbut, Dinan, and Young[27] found that women over 80 years of age could increase their aerobic capacity, at baseline their aerobic state was such that "even in health, most women over 80 would experience difficulties in the performance of everyday tasks" (p. 259). Furthermore, Bootsma-van der Weil et al.[3] found that only 5% of the oldest-old population they studied were competent in their IADL, and 22% of the women and 10% of the men were unable to perform ADL. Cognitive difficulties, decreased aerobic state, and functional inability may all contribute to frailty, but they are not the only factors as shown in this study.

As Canadian population demographics continue to change, and the population explosion among the Oldest-Old becomes reality, there is little doubt that frailty will become increasingly prevalent[10]. Increased demands on family and healthcare system resources will accompany this demographic shift. Decreased functional independence will increase seniors' dependence on family and friends. Increased morbidity, mortality, and institutionalization of the elderly population with large consumption of monetary, technical, and human resources will follow. If this unnecessary and costly result is to be avoided, then the factors that contribute to frailty must be identified. Understanding the factors that contribute to frailty will assist policy makers and healthcare workers to focus their resources in the most effective preventative and rehabilitative areas. It will also help to decrease fragmentation and further develop frailty theory.

IV. Design

This thesis is comprised of two papers: 1) an integrative review of theoretical and research literature that addresses question #1, and 2) an empirical paper assessing the ability of the chosen framework to identify factors contributing to frailty in the oldest-old that addresses question #2.

V. Theoretical Framing

Choosing one appropriate theory to study frailty was difficult because most theories in the area are underdeveloped. Frailty theory must acknowledge the multifaceted aspect of the syndrome including environmental and social factors. Many theories espouse these values, but they do not operationalize the non-physical variables. The framework chosen for this study, Brown, Renwick, and Raphael[6] and a second publication by Rapheal et al.[33], asserts that frailty is a social construct that occurs when "there is diminished ability to carry out the important practical and social activities of daily living" (p. 96), (p. 225). Factors contributing to frailty are categorized into personal or environmental. *Personal factors* are immediate current states that influence daily functioning, and are dependent on the individual. Personal factors include cognitive, physical, psychological, and spiritual states. Examples of personal factors that contribute to frailty are dementia, weakness, depression, and hopelessness. *Environmental factors* are conditions associated with the individual states that influence daily functioning but are dependent on the individuals' surroundings. Environmental factors include financial, interpersonal, living, and legal conditions. Examples of environmental factors that contribute to frailty are lack of income, social isolation, living in a dangerous neighbourhood, and loosing drivers' license. Interdependence between the personal and environmental factors can increase or decrease the level of frailty. Both sets of factors can modify the other, thereby creating a situation supporting the progression of frailty or buffering against it. The factors identified by the authors are not exhaustive, but are used as examples to help clarify the physical and environmental concepts.

Using a continuum, Brown, Renwick, and Raphael[6] place frailty at the opposite end of hardiness allowing for movement back and forth along the continuum. Using a continuum to conceptualize frailty acknowledges the interaction between physical and environmental factors, and this is important when discussing the Oldest-Old. For example, an independent senior who suffers from an acute urinary tract infection, and who does not have the proper environmental factors to compensate will fall on the frail side of the continuum. Once the infection is treated and the senior returns to his or her pre-infection state, movement will occur back towards the hardy end. If however, the infection leads to a second illness, the senior will move further along the continuum and become increasingly frail. Frailty is not a static state, but is a dynamic state with differing levels of frailty and seniors can move along the continuum depending on their resources.

The concept of reserve capacity is frequently discussed in the frailty literature, and reserve capacity plays an important role in this theory. It refers to the assets one has in order to sustain change with a positive outcome. These assets are not the resources needed for everyday living, but are the 'extra's' that can be stored up to deal with unexpected events such as illness or trauma. The capacity to deal with extra demands, plus the personal and environmental factors previously mentioned, play an interconnected role in the occurrence of frailty. Any of the factors can result in movement on the continuum toward either frailty or hardiness. Physical and environmental factors play a major role in everyday challenges, and reserve capacity plays a major role in unusual or acute challenges.

Appendix A is a model representation of the theory chosen to guide this study. Appendix B is a comparison of contributing factors identified in the theory and those available in the data set. The majority of contributing factors identified in Brown, Renwick, and Raphael[6] model were

available in the data set. Some factors not identified in the model were added because they fit with the theory and have been identified by other theorists as contributing to frailty.

VI. Methods

Phase One – literature review

A systematic review of theoretical and research literature was conducted using the databases Medline (1966 to July week 1 2004), CINAHL (1982- July week 1 2004), PsychInfo (1985- July week 1 2004), and Ageline (1995- July week 1 2004). Inclusion criteria included: (1) a clear theoretical or operational definition of frailty; (2) clear identification of factors that contributed to or could predict frailty; and (3) published in English. Exclusion criteria included: (1) studies that identified factors that correlated with frailty but did not specify the direction of the relationship (direction of relationship could be clearly stated, or implied by the statistical methods used); (2) sample included only institutionalized elderly; and (3) studies that were tautologies, i.e., the independent and dependent factors were essentially the same.

Phase Two – empirical paper

A. Survey and Data Collection

To identify the factors contributing to frailty in the Oldest-Old, this study used data previously gathered by Statistics Canada. "Secondary analysis involves the creation of a research project based on a reanalysis of data previously collected for other purposes"[31](p. 157). The National Population Health Survey[36] (NPHS) is a national survey collected by Statistics Canada looking at the health of Canadians, excluding those living on Indian Reserves, Canadian Forces Bases, and remote areas in Quebec and Ontario. The first three cycles in 1994-1995, 1996-1997, and 1998-1999 included both a cross-sectional and longitudinal sample. Starting in fourth cycle, 2000-2001, the survey became longitudinal only. With each cycle there is a core set of questions as well as questions specific to the content of that cycle. Each new wave of the NPHS contains different questions, and therefore variables necessary to this study were not available in all data sets. For this reason, the cross-sectional sample from the 1994 survey is used for this study. A general assessment of every person in the household, as well as an in-depth assessment of one person over the age of 12 in the household constitutes the data set. Demographics and economic information, use of health care services, health determinants, and health status are some of the areas addressed in the survey. The sampling methodology used for the survey involved a multi-stage stratified sample of dwellings selected within clusters based on the Labour Force Survey. Provinces are divided into 'areas' then further divided into 'strata', and finally into 'clusters'. The variables are weighted to promote valid representation of the population. For a more detailed description of the weighting procedures used for the NPHS refer to Appendix F.

B. Analysis

The first step in this study was to operationalize the dependent variable so that the continuum of frailty and reserve capacity as discussed in the theoretical framework was reflected. Due to the differences in scaling of the individual items, Principle Component Analysis (PCA) was chosen to combine nominal, ordinal, and interval items. The result was one

variable ranging from hardiness (able to carry out all practical and social activities) to frailty (unable to carry out all practical and social activities). Next, multiple linear regression was used to identify items significantly contributing to frailty in the Oldest-Old.

VII. Results

Phase One – literature review

In total, 18 articles met the inclusion criteria and were included in this review. The final set of literature included 7 research articles, and 11 theoretical articles. Frailty was defined 10 different ways in the 11 theoretical articles included. All of the research articles included in this review were comparative in design describing the differences between the frail and non-frail groups. The majority were secondary data analysis performed on large prospective studies. Many of the factors discussed in the theoretical articles appeared as contributing factors in the research articles. Regardless of how frailty was defined, there were some similar contributing factors identified in the theoretical and research literature. Aging, disease, physical inactivity and weakness, cognitive/psychological difficulties, socio-economic status, malnutrition, and social involvement/interaction were all identified as contributing to frailty.

The literature review has been submitted to the *Journal of Advanced Nursing.*

Phase Two – empirical paper

The theoretical framework developed by Brown, Renwick, and Raphael[6] guided the choice of variables in this study. Their framework views frailty as more than physical difficulties, and includes difficulty with performing social activities as well. Support for this view of frailty was found with this study. Using the contributing factors identified in the theoretical framework, almost 50% of the variance for frailty was explained. Findings such as the contribution of decreased mobility, activity, and cognition support those in both the theoretical and the research literature[7, 12, 15]. Two findings that are new with this model are the impact of mastery and religious attendance on frailty. Mastery has been linked to health in seniors[14, 22], but the connection between mastery and frailty is new. The variable religious attendance has been used as an indicator of social activities in other studies[38] and for this study it was used as a proxy for social support and social activity. Most of the physical factors thought to contribute to frailty were available in the NPHS. Psychological and interpersonal factors were not useable due to the distribution of the variables. Other factors such as living situation or legal issues or were not available in the NPHS. Even without the availability of these variables, the model appears to be adequate at predicting factors contributing to frailty in the oldest-old.

The empirical paper has been submitted to the *Canadian Journal of Aging.*

VIII. Conclusions

The findings from these two papers both support and add to what is known about factors that contribute to frailty. There is a strong physical component of frailty, but there is also a strong social and psychological component. Frailty is different from functional decline, and many of the contributing factors lend themselves to intervention.

IX. Contribution

Frailty Theory

Findings from the work done here support the guiding theoretical framework in its definition of frailty and identification of factors contributing to frailty. They also support the importance of differentiating frailty from functional decline or functional dependence by including a measure of social activities limitation.

Frailty Research

This study has assessed the adequacy of Brown, Renwick, and Raphael's[6] model and concluded that this model has potential for identifying factors that contribute to frailty. This research has also used an innovative method for operationalizing frailty in a way that reflects both a continuum and reserve capacity. It has supported many of the physical factors believed to contribute to frailty, and identified other psychological and social factors that have not previously been identified.

Nursing Practice

This study lends support to the use of a theoretical framework that defines frailty in a novel way and clearly identifies potentially preventable factors contributing to frailty. As more and more nurses are drawn to the field of gerontology, being able to clearly identify what is frailty and how to prevent the onset or slow-down the progression will help to keep seniors healthy in their later years. Prevention and intervention will help to add quality to the life of seniors.

X. Limitations

1. The inclusion/exclusion criteria used for the literature review may have been too limiting. There are studies that examine different ways to measure and define frailty, but if clear identification of what they believed was contributing to frailty was absent, than it was not included.

2. Some of the factors thought to contribute to frailty were not available in the NPHS.

3. Due to the age group included in this study, a proxy was used to answer the questions when the senior was unable. This may have influenced the responses.

4. Finally, social desirability when answering the questions may have played a factor in how the participant responded.

XI. Ethics

The data used for this study comes from the 'Public Use' files created from the master file collected by Statistics Canada. Protection of participants anonymity is guaranteed in the Public Use file, and Statistics Canada has ensured client confidentiality and identifiable data is

prohibited under the Statistics Act. According to the Graduate Faculty Council at the University of Alberta section 66.10.2[17], approval from the Research Ethics Board is needed when identifying information is involved. No identifying information is available in the 'Public Use' files of the NPHS, and therefore ethical approval is not required. A copy of this proposal along with a letter notifying Dr. Allen, Associate Dean of Research and Graduate Studies, that based on the GFC Policy 66.10.2 this thesis does not require ethical clearance.

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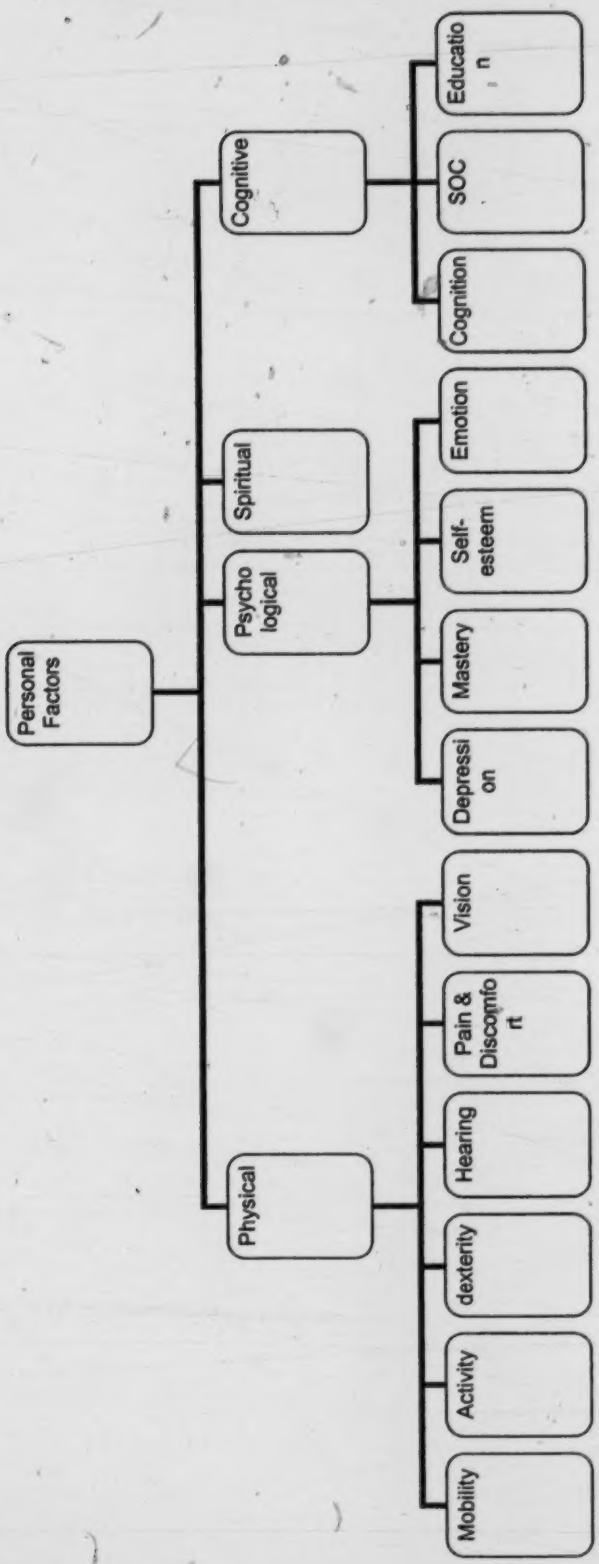
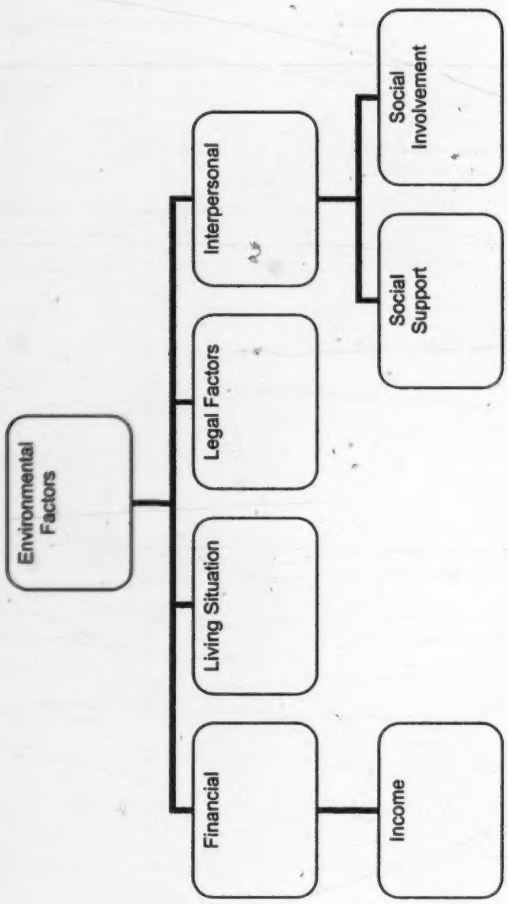
Appendix1- A: Personal Factors



Appendix 1-B:*Environmental Factors*



Appendix 1-C: *Comparison of Theory and NPHS*

	Theory	NPHS	Variable Name
Physical			
	Mobility	Mobility	DVMOBFG
	Agility	Dexterity	DVDEXFGF
	Pain	Pain & Discomfort	DVPAAF94
	Loss of Energy	Activity	DVDAFQ94
	Hearing Loss	Hearing	DVHEAFG
	Vision Loss	Vision	DVISFG
	Not mentioned	Nutrition	B_Q01
Psychological			
	Depression	Depression	DVSFS94
	Emotional Disturbance	Emotion Attribute	DVEMGF94
	Psychiatric Disorders	Not Available	
	↓ sense of self-worth	Self-esteem	DVESTI94
	Not Mentioned	Mastery	DVMASI94
Cognitive			
	↓Intellectual Functioning	Sense of Coherence	DVSCI94
	Memory Loss	Cognition	DVCOGFG
	Not Mentioned	Level of Education	DVEDC294
Spiritual			
	Loss of Hope	Not Available	
	↓ altruistic behavior	Not Available	
Financial			
	↓ funds to live on	Level of Income	DVINC594
	↓ material possessions	Not available	
	↓material resources	Not Available	
Interpersonal			
	Availability of family, friends, acquaintances	Perceived social support	DVSSI194
	Social Activities	Religious Attendance	SUP-Q2A
Living Situation			
	Home Hazards	Not Available	
	Dangerous Neighborhood	Not Available	
	Distance from Stores	Not Available	
Legal Factors			
	License to Drive	Not Available	
	Control over personal finances	Not Available	

Factors Contributing to Frailty: an integration of theory and research literature.

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Factors Contributing to Frailty: An integrative review

One of the greatest challenges society faces in the next 10 years as our population ages is frailty. According to Statistics Canada and the United States Census Bureau, those who are 80 years of age and older are the fastest growing population segment in North America (Health Canada, 2003; Hetzel & Smith, 2000). With these changing demographics looming in the near future, the potential consequences are a frequent topic in the gerontological literature. Frailty, which increases morbidity, mortality, falls, and institutionalization (Fried et al., 2001), will increase the likelihood of potential adverse consequences such as an increased strain on the healthcare system and on family structures. Frailty is most prevalent among the old, especially those who are 80 years of age or more (Bales & Ritchie, 2002; Bowsher, Bramlett, Burnside, & Gueldner, 1993). Frailty is a syndrome that many working in the field of gerontology have difficulty defining. Intensive studies and large-scale studies such as the Canadian Initiative on Frailty and Aging (Canadian Initiative on Frailty and Aging, 2003) and the FISIT trials in the United States (Ory et al., 1993) are trying to shed light on the definition of frailty, and the best interventions for its treatment. Additionally, frailty increases demands on family and friends as independence falters, adversely affecting quality of life (Hamermann, 1999).

We could not locate a published review that examined the factors contributing to frailty. Identification and integration of the factors contributing to frailty from theoretical and research literature will assist geriatric care teams in developing treatment strategies for the frail population. Healthcare workers will be better able to initiate effective prevention strategies and delay the onset of this syndrome. Policy makers will be better

informed when making resource allocation decisions about geriatric care. In addition, identification of contributing factors will help advance frailty theory and aid the design of prevention and intervention research programs. The purpose of this review was to integrate the theoretical and research literature identifying factors that contributing to frailty. Review papers often include only research literature but we felt it necessary to incorporate theoretical literature to identify concordance and conflict between the two different sets of literature. The research question "What factors contribute to, or predict frailty" guided our review. We reviewed both theoretical and research articles to ensure all possible contributing factors were identified, and to compare the factors identified in both groups of literature. The paper unfolds as follows: identification of common factors in the literature; discussion summarizing the common factors in first the theoretical and then the research literature, assessment of the quality of the studies, and identification of the work needed to further frailty theory.

Methods

Search Strategy

Databases searched included Medline (1966 to July week 1 2004), CINAHL (1982- July week 1 2004), PsychInfo (1985- July week 1 2004), and Ageline (1995- July week 1 2004). The key terms used in the literature search are shown in Table 1. The references of retrieved articles were checked to ensure all relevant articles were reviewed and examined for a fit with our inclusion criteria. The majority of articles retrieved were from medical journals, and the rest from other healthcare disciplines such as rehabilitation, nursing, and nutrition. The concept of frailty was introduced 20 years ago by Monsignor Charles F. Fahey and the Federal Council on Aging (Hogan, MacKnight,

& Bergman 2003), and although no year limit was put on the search, the majority of articles retrieved were published between the years 1990 and 2001.

Insert Table1 about here

Inclusion Criteria

Inclusion criteria for both theoretical and research articles included: (1) a clear theoretical or operational definition of frailty; (2) clear identification of factors that contributed to, or could predict frailty; and (3) published in English. Exclusion criteria included: (1) studies that identified factors that correlated with frailty but did not specify the direction of the relationship (direction of relationship could be clearly stated, or implied by the statistical methods used); (2) sample included only institutionalized elderly; and (3) studies that were tautologies, i.e., the independent and dependent factors were essentially the same.

In total, 18 articles met the inclusion criteria and were included in this review. The final set of literature included 7 research articles, and 11 theoretical articles. The research articles were evaluated using a validity tool (See Appendix A) adapted from Estabrooks et al. (Estabrooks, Floyd, Scott-Findlay, O'Leary, & Gushta, 2003) to assess robustness of each study. Each article was evaluated on design, sample, measurement and analysis. The highest possible score was 14 and the lowest possible score was 0, and it was decided that articles scoring less than five would be eliminated. (See Table 2 for validity results). None of the studies that met the inclusion criteria were eliminated due to scores on the validity tool. We did not use a tool to evaluate the theoretical articles. Characteristics of the studies are presented in Table 3.

Insert Table 2 and 3 here

Results

Initial searches resulted in 134 articles of which 18 articles met the inclusion criteria. The majority of studies were excluded due to an absence of a clear definition of frailty, or a focus on the outcomes, impact, or interventions of/for frailty without clearly defining what factors were contributing. The major findings extracted from the theoretical literature are presented in Table 4. The major findings extracted from the research literature are presented in Table 5.

Insert Tables 4 and 5 about here

Theoretical Literature

Identification of the factors contributing to frailty depended on the theory and definition used by the investigators. Some theories gave primacy to the physiology of the ageing body (Buchner & Wagner, 1992) or cellular and system level function (Bortz, 1993; Bortz, 2002; Hamermann, 1999; Lipsitz, 2002). Other theories were more holistic, accounting for social and environment factors that contribute to frailty in addition to the physiological changes (Brown, Renwick, & Raphael, 1995; Fried & Walston, 1999; Morley & Perry, 2002; Rockwood, Fox, Stolee, Robertson, & Beattie, 1994).

Frailty was defined 10 different ways in the 11 theoretical articles included, and a different way in each of the research articles. These definitions are summarized in Appendix B and C. Regardless of how frailty was defined, common contributing factors were identified. The two most identified contributing factors were disease and ageing. Authors such as Lipsitz (Lipsitz, 2002) identified only age and disease as the factors that contribute to frailty. Another common factor was decreased physical activity resulting in outcomes such as sarcopenia, muscular weakness, loss of energy, or decreased mobility

and agility (Bales & Ritchie, 2002; Bortz, 1993; Bortz, 2002; Buchner & Wagner, 1992; Brown et al., 1995; Fried & Walston, 1999; Morley & Perry, 2002; Rockwood et al., 1994). Nutritional deficits and its consequences, such as unintentional weight-loss, were also identified in four of the articles (Bales & Ritchie, 2002; Bortz, 2002; Fried & Walston, 1999; Morley & Perry, 2002). Socio-economic factors, such as income and education, were identified in three articles (Brown et al., 1995; Morley & Perry, 2002; Rockwood et al., 1994). Social factors, such as having someone to count on in time of need, were identified in three articles (Brown et al., 1995; Morley & Perry, 2002; Rockwood et al., 1994), and cognitive/psychological factors were identified in four articles (Brown et al., 1995; Rockwood et al., 1994; Fried & Walston, 1999; Morley & Perry, 2002).

Research Literature

Many of the factors discussed in the theoretical articles appear as contributing factors in the research articles even though the definitions varied (see Appendix B). However, there were a greater number of factors in the research articles. Disease, whether measured as one specific disease or a sum of diseases, was found to contribute to frailty (Chin A Paw, Dekker, Feskens, Schouten, & Kromhout, 1999; Fried et al., 2001; Leng, Chaves, Koenig, & Walston, 2002; Nourhashemi et al., 2001; Strawbridge, Shema, Balfour, Higby, & Kaplan, 1998). Physical inactivity represented by items such as balance, gait, or strength was also identified as a contributing factor (Brown, Sinacore, Binder, & Kohrt, 2000; Chin A Paw et al., 1999; Dayhoff, Suhrheinrich, Wigglesworth, Topp, & Moore, 1998; Fried et al., 2001; Strawbridge et al., 1998). Four studies identified cognitive/psychosocial variables as contributing factors (Chin A Paw et al.,

1999; Fried et al., 2001; Nourhashemi et al., 2001; Strawbridge et al., 1998). Two studies identified nutritional issues contributing to frailty (Nourhashemi et al., 2001; Strawbridge et al., 1998). Three studies identified socio-economic variables contributing to frailty (Fried et al., 2001; Nourhashemi et al., 2001; Strawbridge et al., 1998).

The quality scores of the seven identified studies were all five or more using the validity tool, so all were retained in the review. All of the included articles were comparative in design and the majority were secondary data analyses performed on large prospective studies (see Table 2). The study designs were appropriate for the purpose and research question(s) stated. Most articles received lower scores on the validity tool because frailty was self-reported rather than observed, or if it was observed the psychometrics of the scale were not reported. Reliability and validity of some measures were reported in three of the seven research articles. The article that scored the lowest had a small, non-random sample.

Sample size in the studies ranged from 30 (Leng et al., 2002) to 7364 (Nourhashemi et al., 2001). The subjects for the majority of the studies included both men and women, but one study included only women (Nourhashemi et al., 2001) and one included only men (Chin A Paw et al., 1999). Mean age of subjects ranged from 73 (Dayhoff et al., 1998) to 85 (Leng et al., 2002) with the mean age of those diagnosed as frail always older than those in the non-frail group. The reported age ranges for the studies were as narrow as 60 to 88 (Dayhoff et al., 1998) and as wide as 65 to 102 (Strawbridge et al., 1998). The reported mean number of chronic diseases/illnesses for subjects ranged from two to four. The majority of studies measured frailty as a categorical variable; therefore, techniques such as logistic regression (Chin A Paw et al.,

1999; Fried et al., 2001; Nourhashemi et al., 2001; Strawbridge et al., 1998) and discriminant analysis (Dayhoff et al., 1998) were used in the final analysis. The measurement of frailty and factors contributing to frailty varied throughout the studies with the majority focusing on physical aspects.

Integration of Findings

Ageing as a predictor of frailty was identified in four of the theoretical articles (Bortz, 1993; Buchner & Wagner, 1992; Fried & Walston, 1999; Lipsitz, 2002); and was reported as a contributing factor in three research articles (Fried et al., 2001; Nourhashemi et al., 2001; Strawbridge et al., 1998). Two studies included age as an independent predictor but did not find a significant relationship (Dayhoff et al., 1998; Leng et al., 2002). Even though ageing as a contributing factor was not mentioned in the other research articles, there was an indirect declaration of the belief in a relationship as evidenced by the populations chosen to study frailty. All of the studies chose population samples over the age of 60, thereby implying a relationship between frailty and ageing.

The contribution of disease to frailty was identified in nine of the theoretical articles (Bales & Ritchie, 2002; Bortz, 1993; Bortz, 2002; Brown et al., 1995; Buchner & Wagner, 1992; Fried & Walston, 1999; Hamermann, 1999; Lipsitz, 2002; Morley & Perry, 2002), and was found to be significant in five of the research articles (Chin A Paw et al., 1999; Fried et al., 2001; Leng et al., 2002; Nourhashemi et al., 2001; Strawbridge et al., 1998). Disease was measured as one of: (a) the contribution of various individual diseases (Fried et al., 2001; Nourhashemi et al., 2001), (b) a summation of the number of diseases (Chin A Paw et al., 1999), or (c) a chronic low-grade inflammation not resulting from a specific disease (Leng et al., 2002). Diseases of the cardiovascular system and

diabetes were identified in three research articles as major contributors to frailty (Chin A Paw et al., 1999; Fried et al., 2001; Nourhashemi et al., 2001).

There was support for the contribution of physical inactivity and its effects on frailty. Physical inactivity and its results of sarcopenia or decreased strength and balance were identified in all but two of the theoretical articles (Bales & Ritchie, 2002; Bortz, 1993; Brown et al., 1995; Buchner & Wagner, 1992; Fried & Walston, 1999; Morley & Perry, 2002; Raphael et al., 1995; Rockwood et al., 1994; Bortz, 2002), and found to be significant in five of the research articles (Brown et al., 2000; Chin A Paw et al., 1999; Dayhoff et al., 1998; Fried et al., 2001; Strawbridge et al., 1998). The contribution of physical inactivity and its side-effects to frailty were measured in a variety of ways including both observable items and questionnaire items. The most frequently measured items were balance (Brown et al., 2000; Chin A Paw et al., 1999; Dayhoff et al., 1998), gait (Brown et al., 2000; Chin A Paw et al., 1999; Fried et al., 2001), and strength (Brown et al., 2000; Chin A Paw et al., 1999; Dayhoff et al., 1998). Different aspects of physical inactivity were used by Chin A Paw et al. (Chin A Paw et al., 1999), Fried et al. (Fried et al., 2001), Leng et al. (Leng et al., 2002), and Strawbridge et al. (Strawbridge et al., 1998) in both the operationalization of frailty and as a predictor of frailty. Regardless of how they were measured, this group of contributing factors was reported as significant in all studies that included them.

The contribution of cognitive/psychological factors was identified in four theoretical articles (Brown et al., 1995; Fried & Walston, 1999; Morley & Perry, 2002; Rockwood et al., 1994) and supported in four of the research articles (Chin A Paw et al., 1999; Fried et al., 2001; Nourhashemi et al., 2001; Strawbridge et al., 1998). The

contribution of cognition to frailty was assessed using the Mini-Mental State Examination (Chin A Paw et al., 1999; Fried et al., 2001) and the Pfeiffer test (Nourhashemi et al., 2001). Psychological factors, such as depression and self-assessed health, were assessed using a questionnaire (Chin A Paw et al., 1999; Fried et al., 2001; Nourhashemi et al., 2001). Fried et al. (Fried et al., 2001) and Nourhashemi et al. (Nourhashemi et al., 2001) identified cognition as a factor contributing to frailty, while Strawbridge et al. (Strawbridge et al., 1998) included cognition as part of their operational definition of frailty. Dayhoff et al. (Dayhoff et al., 1998) used the psychological measure of self-rated health as part of their operational definition of frailty. All studies that included these variables found them to be significant contributors to frailty.

Socio-economic factors were discussed in three of the theoretical articles (Brown et al., 1995; Morley & Perry, 2002; Rockwood et al., 1994), and were found to be significant in three research articles (Fried et al., 2001; Nourhashemi et al., 2001; Strawbridge et al., 1998). The assessment of socio-economic factors included items such as level of education (Fried et al., 2001; Strawbridge et al., 1998; Nourhashemi et al., 2001) and income (Nourhashemi et al., 2001; Fried et al., 2001). None of the authors used socio-economic factors in their definition of frailty.

The contribution of malnutrition to frailty was identified in three theoretical articles (Bales & Ritchie, 2002; Bortz, 2002; Fried & Walston, 1999; Morley & Perry, 2002), and supported in two research article (Nourhashemi et al., 2001; Strawbridge et al., 1998). Nutritional status was measured using weight and Body Mass Index (BMI). However, in the majority of the research studies, BMI was not considered to be a

contributing factor, but was used in the operationalization of the dependent variable instead (Chin A Paw et al., 1999; Fried et al., 2001; Leng et al., 2002; Strawbridge et al., 1998) .

Social factors were identified in three theoretical articles (Brown et al., 1995; Morley & Perry, 2002; Rockwood et al., 1994), and supported in three research articles (Fried et al., 2001; Nourhashemi et al., 2001; Strawbridge et al., 1998). Nourhashemi et al. (Nourhashemi et al., 2001) found that social activities such as taking holidays and participating in senior citizens clubs had a negative relationship with their measure of frailty, while receiving visits from family and friends had a positive relationship. Brown, Renwick, and Rapheal (Brown et al., 1995) used social involvement as part of their theoretical definition of frailty and identified the availability of social support and activities as a potential contributing factor. Strawbridge et al. (Strawbridge et al., 1998) found that social isolation as measured by having fewer than three close friends or relatives, or having little contact with friends or family in the past three months predicted frailty.

Finally, the contribution of physical functioning to frailty was not identified in any of the theoretical articles, but was found to be significant in four of the research articles (Brown et al., 2000; Chin A Paw et al., 1999; Fried et al., 2001; Nourhashemi et al., 2001). Physical functioning was measured as ability to perform ADL (Chin A Paw et al., 1999; Nourhashemi et al., 2001), IADL and ADL (Fried et al., 2001), or sensory difficulties (Brown et al., 2000; Nourhashemi et al., 2001). Physical functioning was often used to define frailty (Brown et al., 2000; Brown et al., 1995; Dayhoff et al., 1998; Nourhashemi et al., 2001; Strawbridge et al., 1998). There appears to be an important

relationship between physical functioning and frailty, but it has yet to be determined if decreased physical functioning leads to frailty or vice-versa.

Discussion

In this review, we integrated the theoretical and research literature identifying factors that contribute to frailty. Because no unified definition of frailty exists, we did not limit the inclusion of studies based on a definition of frailty, thereby allowing for a broad range of theories and research. We were open to the inclusion of any definition as long as it was clearly identified. In three of the research articles the authors defined frailty strictly as a physical syndrome (Chin A Paw et al., 1999; Fried et al., 2001; Leng et al., 2002), in two articles frailty was defined as functional difficulty (Brown et al., 2000; Nourhashemi et al., 2001), in one article as a combination of functional impairment and poor self-rated health (Dayhoff et al., 1998), and finally in one article as a syndrome involving dysfunction in a broad spectrum of domain (Strawbridge et al., 1998). Regardless of the differences in definitions, many of the identified factors were similar as shown in the results section, therefore suggesting that a possible unified definition of frailty is within reach.

While there is strong agreement that there is a relationship between many of the identified factors and frailty, there is not agreement as to whether the factors are contributors to or outcomes of frailty. Factors identified as contributors in some articles were used in the operationalization of the dependent variable in other articles. This creates confusion as to which occurs first, frailty or the factor? This problem occurs with the factors of cognition/psychological, nutrition, and functional ability. For example, Dayhoff et al., (Dayhoff et al., 1998) included functional disability in ADL's as part of

their operationalized definition, while others identified ADL dysfunction as a predictor (Chin A Paw et al., 1999; Fried et al., 2001; Nourhashemi et al., 2001). Much of this confusion stems from how frailty is conceptualized.

Spirituality, a factor that has been identified as contributing to seniors health and wellbeing (Krause, 2002; Meisenhelder, 2003), was not included as a possible contributing factor in any of the studies. Only Brown, Renwick, and Raphael (Brown et al., 1995) included spirituality as a factor contributing to frailty in their theoretical framework. Strawbridge et al. (Strawbridge et al., 1998) chose to use attendance at religious services as an indicator of social activities and found that it was not statistically different between those who are frail versus those who are not frail. Considering the potential impact this factor has on seniors' health and well-being, it will be wise for future researchers to include this in their study.

One factor that did not appear in the research articles but was often discussed in the theoretical literature is reserve capacity (Bales & Ritchie, 2002; Bortz, 2002; Brown et al., 1995; Buchner & Wagner, 1992; Lipsitz, 2002; Woodhouse, Wynne, Baillie, James, & Rawlins, 1988). The idea of reserve capacity is present in almost all theoretical or conceptual definitions of frailty, although not all authors are as explicit about its inclusion. Reserve capacity is based on the assumption that most organs can sustain a 70% loss of function before an failure becomes evident (Bortz, 1993; Bortz, 2002). The reduced ability to adapt due to lack of reserves creates an unstable situation. Campbell and Buchner (Campbell & Buchner, 1997) take the idea of reserve capacity even further, identifying the specific bodily systems that require a reserve to prevent frailty. According to these authors, a reserve capacity is needed in the musculoskeletal, neurological,

nutritional, and aerobic systems if frailty is to be avoided. Regardless of whether the need for reserve capacity is present in specific body systems, or if it is present in all body systems, most authors have included it in their theoretical definition of frailty. Finding a valid and robust measure of reserve capacity will help to clarify its role in frailty.

Increasingly, awareness of the importance of frailty is occurring amongst gerontologists and geriatricians. This review, by integrating theoretical and research literature, has helped to highlight overlap and agreement between theory and research, and also the gaps and differences. Future research differentiating frailty from functional dependence will help to clarify contributing factors, and advance frailty theory. Increasingly, theorists need to test their theories to identify areas of strength and weakness. Although there were many common factors identified between the two sets of literature, there was not a large overlap of theories or authors. Many of the authors who wrote about the correlations and relationships between the contributing factors did not clearly identify the theory guiding their research, or they developed their own. If research about frailty is to move forward at this critical time before the baby boomers turn 65, then research must be clearly guided by theory, and the theory must be identified when findings are published. As the demographic shifts in the population occur, the need for a common conceptualization of frailty becomes increasingly important. In order to work towards a common conceptualization, theories must be tested for their strengths to build on and weaknesses to correct. Advancing frailty theory can assist healthcare workers to develop intervention strategies to prevent or slow down frailty. Finally, frailty theory will assist policy makers by highlighting where resources need to be focused for maximum efficacy.

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Appendix 2-A: Validity Tool

Reviewer: _____ Date: _____

Factors Contributing to Frailty in the Oldest-Old
Integrative Research Overview (2004)
Quality Assessment Tool for Correlational Studies

Study: _____ **First Author:** _____

Publication Information: Date: _____ **Journal:** _____

Design:	**No**	**Yes**
Was study prospective?	0	1
Was probability sampling used?	0	1

Sample:	**No**	**Yes**
Was sample size justified?	0	1
Was sample drawn from more than one site?	0	1
Was anonymity protected	0	1
Response rate more than 60%	0	1

Measurement:

	No	**Yes**
Contributing Factors (IVs) [assess for IVs correlated with DV only]		
Are factors measured reliably?	0	1
Is the full range measured?	0	1
Frailty (DV)		
Is Frailty observed rather than self-reported?	0	2
If scale used for frailty, is internal consistency ≥ .70?	0	1
Was full range for Frailty scores used?	0	1

Statistical Analysis:	**No**	**Yes**
If multiple determinants studied, are intercorrelations analysed?	0	1
Is the direction of relationship between variables identified?	0	1
Are outliers managed?	0	1

Total: _____

Overall Study Validity Rating (circle one) **LO MED HI**

(Key: 0-4 = LO; 5–9 = MED; 10–15 = HI)

Appendix 2-B: Theoretical Literature Definitons

Author	Theoretical Definition	Operational Definition
Brown, M et al. (2000)	Difficulty with functional tasks (p. M350)	Based on Modified Physical Performance Test score: book lift, put on and take off a coat, pick up a penny, chair rise, turn 360°, walk 50-ft, one flight of stairs, four flights of stairs, progressive Romberg test (max score 36) 1) 32 to 36 – not frail 2) 25 to 32 – mild frailty 3) 17 to 24 -moderate frailty 4) <17 - excluded
Chin A Paw, Dekker, Feskens, Schouten, & Kromhout (1999)	"physical inactivity combined with either low energy intake, 5-year weight loss, or low BMI" (p. 1015)	Physical inactivity - < 210 min/week Low energy intake - < 7.6 MJ per day 5 year weight-loss – > 4 kg Low BMI – less than 23.5 kg/m^2
Dayhoff et al., (1998)	Frailty is diminished functioning combined with diminished self-rated health (p. 19).	Scoring 21 or more on the World Health Organization Assessment of Functional Capacity combined with a self-report of health as fair or poor • Walking between rooms • Moving around outdoors • Using stairs • Walking at least ¼ mile • Using the lavatory • Washing and bathing • Dressing and undressing • Getting in and out of bed • Feeding oneself • Cutting toenails

		• Doing one's one cooking • Doing light housework • Doing heavy housework • Carrying heavy objects • In comparison with other people your age, how would you judge your state of health?
Fried et al., (2001)		Prefrail is the presence of 1 or 2 and Frail is the presence of three or more of the following: Shrinking - > 10 lbs lost unintentionally in prior year Weakness – grip strength: lowest 20% (by gender, BMI) Poor endurance and energy – self reported exhaustion Slowness – walking time/15 feet: slowest 20% (by gender and height) Low physical activity level-Kcals/week: lowest 20% (males<383 Kcals/week, females <270 Kcals/week
Leng et al. (2002) Note: using the Walston/Fried definition	"a wasting syndrome of older adults, characterized by weakness, fatigue, weight loss, and extreme vulnerability to stressors, that predicts increased morbidity and mortality" (p. 1268)	(Same as above) 1. Unintentional weight loss of more than 10 pounds in the past year 2. Low grip strength by gender and BMI 3. Slow walking speed 4. Subjective exhaustion 4. Low levels of physical activity.
Nourhashemi et al., (2001)	"a combination of deficits or conditions that arise with	Disability with one or more IADL measured by the

	increasing age and contribute to making the elderly person more vulnerable to changes in the surroundings and to stress (p. M228)	Instrumental Activities of Daily Living scale.
Strawbridge et al., (1998)	"a syndrome involving deficiencies in two or more domains involving physical, nutritive, cognitive, and sensory capabilities" (p. S9)	Classified as frail if problems/difficulties were reported in two of the following domains: Physical Functioning • Sudden loss of balance • Weakness in arms • Weakness in legs • Get dizzy or faint when stand up quickly Nutritive Status • Loss of appetite • Unexplained weight loss Cognitive Functioning • Difficulty paying attention • Trouble finding the right works • Difficulty remembering things • Forgetting where put something Sensory Functioning • Vision – difficulty reading a newspaper, recognizing a friend across the street, reading signs at night • Hearing – hearing over the phone, hearing a normal conversation, hearing a conversation in a noisy room. Scores for physical, nutritive, and cognitive were: 1- rarely or never have a problem in the last 12 months

		2 – have a little difficulty 3 - have some difficulty 4 – have a great deal of difficulty Sensory items were scored: 1 – have no difficulty 2 – have a little difficulty 3 – have some difficulty 4 – have great difficulty

Appendix 2-C: Research Literature Definitions

Author	Theoretical Definition	Operational Definition
Brown, M et al. (2000)	Difficulty with functional tasks (p. M350)	Based on Modified Physical Performance Test score: book lift, put on and take off a coat, pick up a penny, chair rise, turn 360°, walk 50-ft, one flight of stairs, four flights of stairs, progressive Romberg test (max score 36) 1) 32 to 36 – not frail 2) 25 to 32 – mild frailty 3) 17 to 24 -moderate frailty 4) <17 - excluded
Chin A Paw, Dekker, Feskens, Schouten, & Kromhout (1999)	"physical inactivity combined with either low energy intake, 5-year weight loss, or low BMI" (p. 1015)	Physical inactivity - < 210 min/week Low energy intake - < 7.6 MJ per day 5 year weight-loss – > 4 kg Low BMI – less than 23.5 kg/m^2
Dayhoff et al., (1998)	Frailty is diminished functioning combined with diminished self-rated health (p. 19).	Scoring 21 or more on the World Health Organization Assessment of Functional Capacity combined with a self-report of health as fair or poor • Walking between rooms • Moving around outdoors • Using stairs • Walking at least ¼ mile • Using the lavatory • Washing and bathing • Dressing and undressing • Getting in and out of bed • Feeding oneself • Cutting toenails

		• Doing one's one cooking • Doing light housework • Doing heavy housework • Carrying heavy objects • In comparison with other people your age, how would you judge your state of health?
Fried et al., (2001)		Prefrail is the presence of 1 or 2 and Frail is the presence of three or more of the following: Shrinking - > 10 lbs lost unintentionally in prior year Weakness – grip strength: lowest 20% (by gender, BMI) Poor endurance and energy – self reported exhaustion Slowness – walking time/15 feet: slowest 20% (by gender and height) Low physical activity level-Kcals/week: lowest 20% (males<383 Kcals/week, females <270 Kcals/week
Leng et al. (2002) Note: using the Walston/Fried definition	"a wasting syndrome of older adults, characterized by weakness, fatigue, weight loss, and extreme vulnerability to stressors, that predicts increased morbidity and mortality" (p. 1268)	(Same as above) 1. Unintentional weight loss of more than 10 pounds in the past year 2. Low grip strength by gender and BMI 3. Slow walking speed 4. Subjective exhaustion 4. Low levels of physical activity.
Nourhashemi et al.,	"a combination of deficits or	Disability with one or more

(2001)	conditions that arise with increasing age and contribute to making the elderly person more vulnerable to changes in the surroundings and to stress (p. M228)	IADL measured by the Instrumental Activities of Daily Living scale.
Strawbridge et al., (1998)	"a syndrome involving deficiencies in two or more domains involving physical, nutritive, cognitive, and sensory capabilities" (p. S9)	Classified as frail if problems/difficulties were reported in two of the following domains: Physical Functioning • Sudden loss of balance • Weakness in arms • Weakness in legs • Get dizzy or faint when stand up quickly Nutritive Status • Loss of appetite • Unexplained weight loss Cognitive Functioning • Difficulty paying attention • Trouble finding the right works • Difficulty remembering things • Forgetting where put something Sensory Functioning • Vision – difficulty reading a newspaper, recognizing a friend across the street, reading signs at night • Hearing – hearing over the phone, hearing a normal conversation, hearing a conversation in a noisy room. Scores for physical,

		nutritive, and cognitive were: 1- rarely or never have a problem in the last 12 months 2 – have a little difficulty 3 - have some difficulty 4 – have a great deal of difficulty Sensory items were scored: 1 – have no difficulty 2 – have a little difficulty 3 – have some difficulty 4 – have great difficulty

Table 2-1

Search Strategy

Frail Frailty Frail Elderly	OR	
AND		
Predictors Contributing factors Cause	OR	

Table 2-2

Evaluation Scores using Validity Tool

Author	Journal	Evaluation Score
Brown, Sinacore, Binder & Kohrt (2000)	Journal of Gerontology: MEDICAL SCIENCES	10
Chin A Paw, Dekker, Feskens, Schouten, & Kromhout (1999)	Journal of Clinical Epidemiology	8
Dayhoff, Suhrheinrick, Wigglesworth, Topp, & Moore (1998)	Journal of Gerontological Nursing	5
Fried et al., (2001)	Journal of Gerontology: MEDICAL SCIENCES	9
Leng, Chaves, Koenig, & Walston (2002)	Journal of the American Geriatrics Society	7
Nourhashemi et al., (2001)	Journal of Gerontology: MEDICAL SCIENCES	10
Strawbridge, Shema, Balfour, Higby, & Kaplan (1998)	Journal of Gerontology: SOCIAL SCIENCES	9

Author(s) and year	Purpose	Sample Size	Subjects	Framework	Study Design and Statistical Analysis	Measurement	Reliability and Validity
Brown, Sinacore, Binder, & Kohrt (2000)	"to examine the relationship of multiple factors believed to be associated with frailty" (p. M350)	107: not frail-39 mildly frail – 48 moderately frail - 20	Men and women living in the community. Average age 83 ± 4 years. Average frailty score 28 ± 4 (mild frailty) Average number of chronic diseases: 3 (arthritis and congestive heart failure being the most prevalent). Age range: not reported.	None identified	Design Comparative Analysis Pearson Correlation ANOVA Bonderroni post hoc testing Stepwise multiple regression	Frailty Modified Physical Performance Test (highest possible score 36) Strength • Knee extensors and flexors - Cybex isokinetic dynamometer • Upper extremeties and proximal musculature of lower extremeties - Hand-held dynamometry, Micro-Fet dynamometer, Jamar dynamometer • Kendall, Kendal, and Wadsworth test for abdominal muscles Range of Motion • Standard goniometric measures • Thomas test Balance • Static balance – functional reach, one leg balance for 30 seconds, and Romberg test • Dynamic balance – balance beam, obstacle course, and fast gait speed	Not reported

						Gait Analysis • Pressure-sensitive foot switches and computer software Coordination and speed of Reaction • Purdue pegboard • Driving simulator Sensation • Light touch and pressure sensation - Semmes-Weinstein monofilaments • Vibration perception – tuning fork	
Chin A Paw, Dekker, Feskens, Schouten, & Kromhout (1999)	"to examine three working definitions of frailty" (p. 1015)	450 total Inactivity/low energy intake – 29 frail and 421 nonfrail *Inactivity/weight loss – 26 frail and 424 nonfrail Inactivity/BMI – 26 frail and 424 nonfrail *Chosen as the most suitable working definition	Independently living men from the Zutphen Study for whom required information was present in both the 1990 and 1993 data sets. Age range: 69 to 89 Mean age: 75 Mean # of diseases: not reported	None identified	Design Comparative secondary analysis using data from Zutphen Elderly Study Analysis Unadjusted means and percentages Logistic regression	Physical Activity: • Questionnaire Nutrition • cross-check dietary history method Health-Related Characteristics • height and weight observed • BMI calculated • Subscapular and tricipital skinfold thickness – caliper • Blood pressure • Serum albumin • Serum total cholesterol Functional Status: • Walking speed • Standing balance • Chair stands	Test-retest correlation r = 0.93 Physical Activity questionnaire - validated

						• External shoulder rotation • Isometric hand grip – Martin vigorimeter • ADLs and IADLs - questionnaire. Cognition: • Mini-Mental State Examination Demographics and Diseases • questionnaire	
Dayhoff, Suhrheinrich, Wigglesworth, Topp, & Moore (1998)	"to develop empirically based criteria for differentiating between frail and nonfrail older adults using measurements of balance and muscle strength and age" (p. 19)	84 total Nonfrail – 69 (7 males, 62 females) Frail – 15 (5 males, 10 females)	Independently community living 60 years of age or older. Age range: 60 to 88 Mean age: 73 Median # of diseases: 2-3	Rockwood et al., (1994) and systems model of balance	Design Comparative Analysis Descriptives Correlations Discriminant Analysis	Frailty: • combination of self report ADL functional and perceived health Balance: • a posturography instrument (Smart Balance Master©) Muscle Strength: • hand-held dynamometer (Microfet©)	Frailty Internal consistency $\alpha = 0.79$ Balance Intratrial correlations ranged from .73 to .85 Muscle Strength Intratrial reliability reported .92 to .97 for dorsiflexion and plantar flexion and test-retest reliability as .85 to .76. Specificity and Sensitivity were done. Check to see if these warrant validity.
Fried et al., (2001)	"to develop and operationalize a phenotype of frailty in older adults and assess concurrent and predictive validity" (p. M146)	5317 total 4735 in original cohort (collected in 1990, 1993, and 1997) and 582 from an African American cohort (collected in 1993 and 1997)	Men and women from four US communities who participated in the Cardiovascular Health Study, and had three or more nonmissing frailty components	None identified	Design Comparative secondary analysis Analysis Cochran-Mantel-Haenszel test	Self-assessed health, weight loss, health habits, medications, diagnosis, and demographics: • interviews Physical Activity: • Minnesota Leisure Time Activities	None reported Frailty measure determined to have concurrent and predictive validity.

			among the five criteria. Age range: 65 to 101 Mean age: Not reported Mean # of diseases: not reported	Overall, 7% of cohort were classified as frail (6% of initial cohort and 12% of African American cohort)	Kaplan-Meier Cox proportional hazard models Covariate-adjusted Cox models Logistic regression	Questionnaire Depression: • modified 10-item Center for Epidemiological Studies-Depression scale Cardiovascular: • medications • electrocardiogram • echocardiogram • posterior tibial-brachial artery systolic blood pressure ratio • carotid ultrasound Cognition: • Mini-Mental State Examination • Digit Symbol Substitution test Physical Ability: • walking speed timed • strength - Jamar hand-held dynamometer Weight, Blood Pressure, Serum Analysis: • phlebotomy	
Leng, Chaves, Koenig, & Walston (2002)	"to test selected physiological parameters as potential correlates of frailty" (p. 50)	30 Total 11 frail 19 nonfrail	Community dwelling adults aged 74 and older from Baltimore, Maryland. Age range: frail group 77-98, nonfrail 74-89)	Fried et al.	Design Comparative Analysis Descriptives Student t test Pearson correlation	Serum interleukin-6 • High Sensitivity Quantikine kit Complete Blood Count: • Coulter counter	Not reported

			Mean age: frail 84.9 ± 6.7, nonfrail 81.3 ± 4.1 Mean # of diseases: frail group 4.3 ± 1.9, nonfrail group 2.6 ± 1.1		coefficient		
Nourhashemi et al., (2001)	To investigate the associations of IADL and correlates of frailty.	7364 total: 5003 – independent (mean age 79.9 ± 3.4) 1130 – dependent in one IADL 540 – dependent on 2 IADL 691 – dependent in more than	Community dwelling females over the age of 75 from the EPIDOS study (a French study examining risk factors for femoral neck fractures) Age range: not reported Mean age: one IADL is 81.0 ± 3.7, 2 IADL is 82.7 ± 4.3, ≥3 IADL is 82.7 ± 4.3 Mean # of diseases: not reported	None Identified	Design Comparative secondary analysis Analysis Chi-square Fisher's exact test Student t Logistic regression	Social and demographic: Not reported • questionnaire Physical Autonomy: • ADL and IADL questionnaire Cognitive: • Pfeiffer's test Falls • Questionnaire Self-rated Health • Questionnaire Height and Weight: • Observed • BMI calculated Whole body composition: • duel energy x-ray absorptiometry	
Strawbridge, Shema, Balfour, Higby, & Kaplan (1998)	To "examine the predictors and prevalence of frailty in a community-dwelling sample	574 (247 men and 327 women) 150 – frail 424 – not frail	Participants of the Alameda County longitudinal study. They were 65 years of age followed from	None identified	Design Comparative Secondary Analysis Analysis	Frailty (questionnaire) • physical functioning • nutrition • cognition • sensory problems	Not reported

of older persons" (p. S9)	1965 to 1994. Age range: 65-102 Mean Age: 74 Mean # of diseases: not reported	Proportion Chi-square Logistic regression	Risk factors (questionnaire): • Alcohol • Obesity - National health and Nutrition Examination Survey II • Smoking • Physical inactivity • Depression-Roberts and O'Keefe scale • Social Isolation • Perceived health • Chronic conditions • Chronic symptoms Quality of Life Measures (questionnaire): • going out for entertainment • visity with family and friends • attending religious services • enjoy free time • felt loved • satisfied with relationships • self-assessed mental health • happiness • depression

Author	Physical Inactivity	Ageing	Disease	Cognitive/ psychological	Spiritual	Socio-economic	Social	nutritional	Living situation	Legal
Bales and Ritchie (2002)	• Sarcopenia • Inactivity		• Disease					• Weight-loss		
Bortz (1993)	• Disuse	• Ageing	• Disease							
Bortz (2002)	• Physical Inactivity • Muscular weakness		• Disease and injury					• Nutritional problems		
Brown, Renwick and Raphael (1995) Raphael et al., (1995)	• Reduced mobility • Reduced agility • Pain • Loss of energy •		• Diminished hearing or sight	• Diminished intellectual functioning • Memory loss • Reduced attentional ability • Depression • Emotional listurbance • Psychiatric lisorders • Decreased sense of self-worth	• Loss of hope • Loss of meaning in life	• Diminished funds to live on • Decrease in material possessions • Reduced material resources available	• Availability of family, friends, or acquaintances • Availability of social activities		• In home hazards • Danger in neighbourhood • Distance from stores	• Loss of drivers license due to age • Loss of control over personal finances
Buchner and Wagner (1992)	• Disuse or abuse	• Ageing	• Disease							
Fried and Walston (1999)	• Falls	• Ageing	• Disease • Illness • Medications • Hospitalizations •	• Depression • Dementia • Stressful life events				• Decreased taste and smell • Poor dentition		
Hamermann (1999)			• Disturbed metabolic balance							
Liptsitz (2002)		• Ageing	• Disease							

Morley, Perry, and Miller (2002)	• Sarcopenia	• Atherosclerosis	• Cognitive impairment	• Low income • Low education	• Social isolation	• Malnutrition
Rockwood, Fox, Stolee, Robertson, and Beattie (1994)	• Physical ability • mobility		• Self-rated health	• Socio-economic factors	• Social resources	

Table 2-5
Findings from Research Literature

Author	Physical functioning	Physical Inactivity	Ageing /Sex	Disease	Cognitive/ psychological	Socio-economic	Social	nutritional
Brown, Sinacore, Binder, and Kohrt (2000)	• Sensation	• Balance • Gait • Range of Motion • Strength						
Chin A Paw, Dekker, Feskens, Schouten, and Kromhout (1999)	• Number of disabilities • ADL difficulties	• Mobility difficulties • Walking speed • Balance • Chair stands • Grip strength		•Physical rated health •Number of diseases	• Self-rated health			
Dayhoff, Suhrheinrich, Wigglesworth, Topp, and Moore (1998)		• Balance • strength						
Fried et al., (2001)	• IADL/ADL difficulties	• Mobility difficulties	• Age • Sex	• Cardiac diseases • Arthritis • Diabetes • Respiratory diseases • Number of chronic diseases • Chronic low-grade inflammation	• Cognition • Depression • Self-assessed health	• Education • income	•living lone	
Leng, Chaves, Koenig, and Walston (2002)								

Nourhashemi, Andrieu, Gillette-Guyonnet, Vellas, Albarede, Grandjean (2001)	• ADL difficulties • Sensory difficulties		• Age	• Diabetes • Stroke • Heart disease	• Cognition • Fear of falling • Self-rated health • depression	• Low income	• Living in a seniors residence • Receiving daily visits	• Fat mass
Strawbridge, Shema, Balfour, Higby, Kaplan (1998)		• Physical inactivity	• Age	• Having tow or more chronic symptoms • Having one or more chronic conditions	• Depression • Poor perceived health	• education	• social isolation	• heavy drinking

Factors Contributing to Frailty in the Oldest-Old

By

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Factors Contributing to Frailty in the Oldest-Old

Frailty is a complex syndrome that slowly erodes seniors' independence at an enormous cost to individuals, family, and society. The onset of frailty is insidious and too often considered a normal part of aging. Increased morbidity, increased mortality, and institutionalization are outcomes of frailty[35]. Frail seniors become increasingly dependent on family and friends, often leading to economic and caregiver burden[2, 47]. Frailty is most prevalent among the old, especially those who are 80 years of age or more[14, 15, 22]. Both Canada and the United States are facing a significant growth in this population cohort[23, 24]. According to the Canadian Initiative on Frailty and Aging[11], from 1991 to 2001 those 80 years of age or older increased by 41% with an expected increase of another 43% over the next 10 years. As society faces these changes in the population demography, interest in the concept of frailty is increasing in the healthcare field. However, there is no universally accepted definition or conceptualization of frailty[5, 25, 30, 36, 37]. Because of this lack of definition, it is difficult to identify factors that contribute to frailty in order to prevent or slow its onset. In order to advance frailty theory, existing frameworks must be closely examined for adequacy and tested empirically. In this study we selected the framework developed by Brown, Renwick, and Raphael[6] to identify factors contributing to frailty. The purpose of this study was to assess the fit between a set of factors identified from the literature, and from Brown, Renwick, and Raphael's[6] conceptualization of frailty. Once a robust set of contributing factors has been acknowledged, preventative and rehabilitative solutions can be identified and tested.

Literature Review

Regardless of how frailty is defined, there are some similar contributing factors identified in the theoretical and research literature. The contribution of aging to frailty is clearly identified in the theoretical literature and supported in the research literature[4, 9, 18, 19, 29, 32, 43]. Studies show significant positive relationships between age and frailty regardless of how frailty is defined. Disease is reported to be a significant contributor to frailty[1, 4, 5, 9, 12, 18, 19, 22, 28, 29, 31, 32, 43]. Physical inactivity is consistently reported as being one of the major contributors to frailty[1, 4, 5, 7, 9, 12, 14, 19, 31, 35, 43]. Cognitive/psychological variables such as self-rated health and depression are identified as contributing factors[6, 18, 19, 31, 32, 35, 43]. Socio-economic factors such as level of income and education are identified as contributing factors[6, 18, 19, 31, 32, 35, 43]. Two other factors identified in the theoretical literature, but less well supported in the research literature are malnutrition[1, 18, 31, 32] and social factors such as isolation[6, 18, 31, 32, 35, 43].

Although many authors are writing theoretical papers discussing different ways of defining frailty, very few test their theory and publish the results. Exceptions to this are Fried and Walston[18] and Rockwood et al.[38] who are among the few authors who have tested their definition of frailty. Often frailty is equated with functional decline which adds to the confusion. Frailty is defined in research studies as a physical syndrome[12, 19, 28], a functional difficulty[8, 32], a combination of functional decline and poor self-rated health[14], and dysfunction in physical, nutritive, cognitive, and sensory domains[43]. In the theoretical literature, frailty is defined as a diminished interaction with the environment[4], a state of muscular weakness[5], a reduced ability to carry out practical and social activities[6, 34], reduced physiological reserve[9], age-related physiologic vulnerability[18], loss

of complexity[29], older persons at risk[31], and a precarious balance between assets and deficits[35]. To advance frailty theory and research, these theories must be tested and improved upon or eliminated.

Purpose

The purpose of this study was to assess the framework of Brown, Renwick, and Raphael[6] and the factors it uses to predict frailty. The study objectives were: 1) to operationalize a definition of frailty that is consistent with the guiding theoretical framework, and 2) to assess those factors within the framework in predicting frailty.

Theoretical Framework

In 1995, two articles were published describing Brown, Renwick, and Raphael's theoretical framework[6, 34]. The authors were part of the North York Community Health Promotion Research Unit in Toronto that was studying frail seniors. To identify frail seniors, the group developed a definition of frailty to reflect physical and social difficulties that they thought illustrated frailty. They defined frailty as the "diminished ability to carry out the important practical and social activities of daily living" [6(p. 94), 34(p. 225)]. Practical activities consist of the functional abilities that are necessary for daily life such as Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL). Social activities include regularly interacting with others, giving and receiving support, involvement in social activities, and helping others. The research group further elaborated on the factors contributing to frailty dividing them into personal and environment groupings. Personal factors are described as "immediate current states"[34(p. 225)] including cognitive, physical, psychological, and spiritual states. Environmental

factors are defined as current conditions that contribute to difficulties including financial, social, living situation, and legal factors.

Also important to this theoretical framework is the concept of reserve capacity. Reserve capacity is mentioned in other frailty frameworks and refers to the resources available to deal with change or unexpected events [10, 19, 29]. Resources can be either physical or social, which means social resources can compensate for physical changes, and vice versa. Seniors who have large amounts of reserve capacity are unlikely to be diagnosed as frail.

Methods

Design

We conducted the study using data from the National Population Health Survey (NPHS) Public Use Files[42] collected by Statistics Canada in 1994. The NPHS is a national survey examining the health of Canadians, excluding those living on Indian Reserves, Canadian Forces Bases, and remote areas in Quebec and Ontario. The first three cycles in 1994-1995, 1996-1997, and 1998-1999 included both a cross-sectional and longitudinal sample. Starting in fourth cycle, 2000-2001, the survey became longitudinal only. With each cycle there is a core set of questions as well as questions specific to the content of that cycle. Each new wave of the NPHS contains different questions, and therefore variables necessary to this study were not available in all data sets. The 1994 data set was chosen because it contained the greatest number of variables identified in Brown, Renwick, and Rapheal's[6] framework. The 1996 and 1998 data set did not contain items for concepts such as self-esteem and mastery. Although the 1994 data set did not contain indicators for every contributing factor identified in the guiding

theory it provided the closest fit with the chosen framework. Because of the steps taken by Statistics Canada to protect the identity of the individuals in this survey, ethics approval was not required[21].

Sample

The sampling methodology used for the NPHS was based on the design of the Labour Force Survey[41]. Using a stratified two-stage sample, provinces are divided into 'areas', then further divided into 'strata', and finally into 'clusters' from which dwellings are chosen. The variables are weighted to ensure that each person in the sample is a valid representation of the individuals like him or her in the general population. We included those participants who were 80 years of age or more as this is the age group where frailty is the most prevalent.

Data Collection

The NPHS was created with consultations from Health Canada and Provincial Ministries of Health. Expert groups of researchers and specialists were consulted to increase content validity. Statistics Canada's *Questionnaire Design Resource Centre* was consulted during questionnaire development. A Computer Assisted Interview (CAI) system was used to conduct the vast majority of interviews (95%). Personal interviews were done for participants without a telephone. Response rate for the survey was 89.7%

Measures

The theoretical and operational definitions and the items used to develop each variable used in the study are given in Appendix A. The dependent variable was derived using Principle Component Analysis (PCA) similar to the approach used by Speechley and Tinetti[40]. First, items were recoded where necessary to reflect increasing frailty with

increasing scores. Next, using one factor PCA, the dichotomous, ordinal, and interval data were combined to operationalize our definition of frailty. This was done so that the data representing practical and social activities of daily living could be combined to represent the *continuum* of frailty as discussed in the theoretical framework. The result is one interval scale variable where those scoring higher are more frail, and those scoring lower are more hardy.

The majority of the independent variables were measured on an ordinal scale. Self-esteem, mastery, and sense of coherence did not require recoding for this study. All other variables were recoded so that as the category increased, the variable of interest also increased.

Most of the contributing factors identified by Brown, Renwick, and Rapheal[6] were available in the NPHS (See Appendix B). All of the physical contributing factors identified in the guiding framework were available plus we added an indicator for nutritional status because this was identified as an important contributor to frailty in the literature. Although there were items to represent most of the psychological factors except psychiatric disorders, the items representing depression and emotional disturbance could not be used in the final regression model due to the skewed distribution of the variable. Level of education was added as a cognitive factor because it was identified as a contributing factor in the literature. Although the availability of friends, family, and acquaintances was asked in the questionnaire, the distribution did allow for the inclusion of this item, so religious attendance was chosen as an indicator of interpersonal factors. Religious attendance is an important part of life for many elderly persons, and we felt that attending religious services was a better indicator of interpersonal factors, such as having

an opportunity to socialize, than it was of spirituality which is about hope and meaning in life in the guiding framework. One item was available to assess the contribution of financial factors to frailty. There were no indicators for spirituality, living situation, or legal factors as defined in the guiding framework.

Data Analysis

The data was analyzed using SPSS® 12.0 for Windows™. First, descriptives of all variables were examined to determine adequate distribution. This resulted in the variables representing depression, dexterity, and social support having to be eliminated because over 80% of the sample population reported no depression, no dexterity problems, and adequate social support. Next, the correlation matrix was examined to ensure a relationship between the dependent and independent variables frailty, and independence among independent variables[44]. Correlations between contributing factors and frailty ranged from -.356 to .615. Correlations among contributing factors ranged from -.457 to .509 (See Table 1).

Insert Table 1 about here

Multiple linear regression was used to examine the contribution of each variable to frailty. Missing data were treated using listwise deletion because no patterns were detected in the cases that had missing data and the sample size was large enough that a significant effect could still be determined after cases with missing data were removed. The final sample size was 419.

Results

In total, there were 498 subjects 80 years of age or more in the NPHS 1994 supplemental data. From this, there were 419 subjects with no missing data. The majority

of the subjects were female, had an elementary school education, had a middle to lower middle income, and were infrequently active. The majority had no mobility problems, were happy and interested in life, and felt they had someone to confide in, count on, look to for advice, and who made them feel loved. The majority experienced no cognitive problems, no pain, and had no sensory problems (hearing), or corrected sensory problems (vision). As for religious attendance, there were two major groups with 31% never attending religious services and 37% attending services weekly.

As shown in Table 2, the regression model used for this study resulted in 50.2% of the variance being explained. The ANOVA results show that the variation explained by the model is significantly different from zero, $F(14, 404) = 29.074$, $p < .000$. The statistically significant factors contributing to frailty are mastery, activity, mobility problems, pain, and religious attendance. Cognitive problems are also statistically significant significant at an alpha level of 0.05. The standardized beta coefficients and t values show that mobility problems followed by activity problems contribute the most to frailty, pain and religion contribute approximately equal amounts, and cognition and mastery contribute the least. All of these contributing factors had a 95% confidence intervals that did not include zero thereby supporting their significance.

Insert Table 2 here

Some items that were correlated at statistically significant levels with the dependent variable were not significant in the regression. Self-esteem, sense of coherence, level of education, income, vision problems, and unhappiness did not contribute at a statistically significant level to frailty in the regression model.

Discussion

The theoretical framework developed by Brown, Renwick, and Raphael[6] guided the choice of variables in our study. Their framework views frailty as more than physical difficulties, and includes difficulty with performing social activities as well. We found support for this view of frailty in our study. Using the contributing factors identified in the theoretical framework, approximately 50% of the variance in our conceptualization of frailty was explained. Findings such as the contribution of decreased mobility, activity, and cognition echo those in both the theoretical and the research literature[7, 12, 14, 19]. Two new findings in our study are the impact of mastery and religious attendance on frailty. Mastery has been linked to health in seniors[13, 17, 26], but the connection between mastery and frailty is new. The variable religious attendance has been used as an indicator of social involvement, but it has not been found to be statistically significant[43]. To ensure religious attendance was not highly correlated with other social involvement variables used to create the dependent variable, we examined the correlations and found the highest correlation at r = -.411. Religious attendance in this study could be a proxy for social support or an opportunity for social activity both of which are identified as contributing factors in the guiding theoretical framework. Nourhashemi et al.[32] found a similar relationship between participating in social activities and frailty. In their study participating in social activities was inversely associated with their definition of frailty.

Another important contribution of this study is that many of the identified contributing factors lend themselves to prevention and intervention. Physical factors such as activity and mobility problems lend themselves to interventions as has been shown in the literature[8, 16, 20, 33, 46]. Other items such as mastery are amenable to intervention

through the promotion of self-efficacy and empowerment[17, 27, 39]. The interventions aimed at social variables such as attendance at religious services require further study.

A unique contribution of this study was the operationalization of frailty in a way that included reserve capacity. Reserve capacity is discussed frequently in both the theoretical and research literature, but few investigators have gone beyond discussing this important concept. In the guiding theoretical framework, reserve capacity can influence a senior's position on the continuum between hardiness and frailty. In this study, frailty was operationalized as a continuum ranging from hardiness on one end to frailty on the other. The closer to the frailty end of the continuum a senior is placed, the less reserve capacity he or she will have. While reserve capacity may not directly contribute to frailty, it can contribute to the severity of frailty.

Finally, in this study we demonstrated that the data fit an existing theory reasonably well, resulting in a useful test of theory with the potential to contribute to ongoing refinement of the theory. The findings from our study add to the validity of the frailty definition of Brown, Renwick, and Raphael[6], our guiding theoretical framework, and support the contribution of decreased mastery, physical activity, and religious attendance, and increased mobility problems, cognitive problems, and pain to frailty.

Brown, Renwick, and Raphael's[6] definition of frailty includes social as well as physical functioning. In our study we used two indicators of social functioning as well as different aspects of physical functioning. The validity of this study is supported by the large amount of variance explained by the model. Their model has potential for identifying factors that contribute to frailty. It should be further tested with the inclusion of factors not available for inclusion in this study, including depression, social support,

and living situation. The important contribution of physical strength and ability to frailty were supported in this study, and intervention studies are ongoing to address these factors[3, 16, 45]. The contribution of more than physical factors is also supported in this study and is in need of further research.

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Table 3- 1: Correlation Matrix

	Frailty	Self-esteem	Mastery	Sense Of Coherence	Level of education	Income	Activity	Vision problem	Hearing problem	Mobility	Unhappy	Cognitive problems	Pain	Religious Attendance	Nutrition
Frailty	1														
Self esteem	-.194**	1													
Mastery	-.261**	.469**	1												
Sense Of Coherence	-.169**	.307**	.509**	1											
Level of education	-.109*	.124**	.080	.098*	1										
Income	-.137**	.189**	.171**	.108*	.285**	1									
Activity	-.356**	.156**	.166**	.181**	.064	.132**	1								
Vision problems	.144**	-.055	-.010	.050	-.032	-.008	-.072	1							
Hearing problems	.066	-.012	-.117*	-.053	-.041	.008	-.064	.088	1						
Mobility	.615**	-.218**	-.163**	-.149**	-.074	-.112*	-.230**	.154**	.104*	1					
unhappy	.175**	-.155**	-.296**	-.457**	-.037	-.016	-.137**	-.042	.033	.091	1				
Cognitive problems	.148**	-.205**	-.215**	-.245**	-.078	-.076	-.040	.040	.078	.074	.138	1			
Pain	.354**	-.166**	-.252**	-.172**	-.0110*	.033	-.076	.030	.047	.331**	.167**	.052	1		
Religious attendance	-.272**	.084	.094*	.075	-.033	.087	.069	-.137**	-.058	-.160**	-.090	-.103*	-.055	1	
nutrition	-.083**	.222**	.259**	.219**	.043	.05151	.108*	.029	-.016	-.067	-.256**	-.130**	-.023	.082	1

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Table 3-2: Regression Results

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-.302	.334		-.904	.367	-.958	.354
	Self-esteem	.016	.014	.046	1.115	.265	-.012	.044
	Mastery	-.027	.010	-.121	-2.650	.008	-.048	-.007
	Sense of Coherence	.006	.004	.069	1.537	.125	-.002	.014
	Level of education	-.015	.021	-.026	-.688	.492	-.057	.027
	income	-.028	.036	-.030	-.795	.427	-.099	.042
	Activity	-.207	.037	-.208	-5.632	.000	-.280	-.135
	vision problems	.037	.046	.029	.813	.417	-.053	.127
	Hearing problems	-.048	.050	-.035	-.967	.334	-.147	.050
	Mobility problems	.425	.035	.478	12.130	.000	.357	.494
	Unhappiness	.119	.074	.065	1.604	.109	-.027	.265
	Cognitive problems	.120	.061	.072	1.955	.051	-.001	.240
	pain	.143	.038	.145	3.740	.000	.068	.219
	Religious Attendance	-.083	.019	-.154	-4.263	.000	-.121	-.045
	nutrition	.020	.036	.021	.563	.574	-.051	.091

$R = .708$
$R^2 = .502$
Adjusted $R^2 = .485$

Variable	Theoretical Definition	Operational Definition	Items	Scoring
Frailty	"a diminished ability to carry out the important practical and social activities of daily living"[6](p. 95)	A combination of IADL and ADLs, frequency of contact with friends and family, plus social participation.	1) Do you need the help of another person in preparing meals? 2) Do you need the help of another person in shopping for groceries or necessities? 3) Do you need the help of another person in doing normal everyday housework? 4) Do you need the help of another person in doing heavy household chores? 5) Do you need the help of another person in personal care? 6) Do you need the help of another person in moving about inside the house? 7) Do you have urinary incontinence diagnosed by a health professional? 8) How often do you have contact with: • Daughter/daughter-in-law • Son/son-in-law • Brothers or sisters	Interval scale ranging from -.10 to +1.68

			• Other relatives • Close friends • neighbors 9)Are you a member of any voluntary organizations or associations such as school groups, church social groups, community centres, ethnic associations or social, civic or fraternal clubs? 9) How often do you participate in meetings for volunteer organizations or associations?	
Mobility	How well the senior can walk and move about to complete daily activities	Level of mobility required to complete daily activities.	1) Are/Is ... *usually* able to walk around the neighbourhood *without* difficulty and *without* mechanical support such as braces, a cane or crutches? 2) Are/Is you/he/she able to walk at all? 3) Do/Does you/he/she require mechanical support such as braces, a cane or crutches to be able to walk around the neighbourhood? 4) Do/Does you/he/she	0 Problems/ Cannot Walk 1 Problems/ Mechanical support 2 Mobility Problems/No Aid 3 No Mobility Problems

			require the help of another person to be able to walk? 5) Do/Does you/he/she require a wheelchair to get around? 6) How often do/does you/he/she use a wheelchair? 7) Do/Does you/he/she need the help of another person to get around in the wheelchair?	
Activity	Amount of energy expended daily	Seniors who are 'active' will average 3.0+ kcal/kg/day of energy expenditure, 'moderate' will average 1.5-2.9 kcal/kg/day, and 'inactive' will average less than 1.5 kcal/kg/day.	1) Have you done any of the following in the past 3 months? (refer to p.g. 24 of questionnaire) 2) In the past 3 months, how many times did you participate in %ACTIVITY%? 3) About how much time did you usually spend on each occasion?	0 Inactive 1 Moderately active 2 Active
Pain and Discomfort	Severity of pain	Having pain or discomfort on a daily basis.	1) Are/Is …*usually* free of pain or discomfort? 2) How would you describe the usual intensity or your/his/her pain or discomfort?	0 No pain or mild discomfort 1 Mild pain/discomfort 2 Moderate pain/discomfort 3 Severe pain/discomfort
Hearing	Hearing ability	It represents the participants usually level	1) Are/Is ... *usually* able to hear what is said in a group	0 Problem hearing/ not corrected

		of hearing, if an aid is needed, and if an aid is used.	conversation with at least three other people *without* a hearing aid? 2) Are/Is you/he/she *usually* able to hear what is said in a group conversation with at least three other people *with* a hearing aid? 3) Are/Is you/he/she able to hear at all? 4) Are/Is you/he/she *usually* able to hear what is said in a conversation with one other person in a quiet room *without* a hearing aid ? 5) Are/Is you/he/she *usually* able to hear what is said in a conversation with one other person in a quiet room *with* a hearing aid?	1Problem hearing/ corrected 2 No hearing problems
Vision	Vision adequacy	It represents the participants usual level of vision, if and aid is needed, and if an aid is used.	1) Are/Is ... *usually* able to see well enough to read ordinary newsprint *without* glasses or contact lenses? 2) Are/Is you/he/she *usually* able to see well enough to read ordinary newsprint *with* glasses or	0 problem seeing close & distant/no sight 1 Problem seeing close/ not corrected 2 problem seeing distant/ not corrected 3 Problems corrected by lenses 4 No visual problems

		contact lenses? 3) Are/Is you/he/she able to see at all? 4) Are/Is you/he/she able to see well enough to recognize a friend on the other side of the street *without* glasses or contact lenses ? 5) Are/Is you/he/she *usually* able to see well enough to recognize a friend on the other side of the street *with* glasses or contact lenses?	
Activity	Physical activity	Have you done any of the following in the past 3 months ? [3] (Read list. Mark all that apply.) ___ Walking for exercise ___ Cross-country skiing ___ Gardening, yard work ___ Bowling ___ Swimming ___ Baseball/softball ___ Bicycling ___ Tennis ___ Popular or social dance ___ Weight-training ___ Home exercises ___ Fishing ___ Ice hockey ___ Volleyball ___ Skating ___ Yoga or tai-chi ___ Downhill skiing ___ Other (specify)	0 Infrequent 1 Occasional 2 regular

			___ Jogging/running ___ Other (specify) ___ Golfing ___ Other (specify) ___ Exercise class/aerobics ___ None DK, R (Go to next section)	
Nutrition	Nutritional adequacy	Participants usual level of nutrition	In general would you say that your eating habits are excellent, very good, fair, or poor?	0 Poor 1 Fair 2 Good 3 Very Good 4 Excellent
Depression	Feelings of sadness that may interfere with daily activities.	The level of depression experienced by participants	1) During the past 12 months, was there ever a time when you felt sad, blue, or depressed for 2 weeks or more in a row? 2) For the next few questions, please think of the 2-week period during the past 12 months when these feelings were worst. During that time how long did these feelings usually last? 3) How often did you feel this way during those 2 weeks? 4) During those 2 weeks did you lose interest in	Higher scores indicate greater depression. Possible range is from 0 'depression' to 8 'depression'

			most things? 5) Did you feel tired out or low on energy all of the time? 6) Did you gain weight, lose weight or stay about the same? 7) About how much did you (gain/lose)? 8) Did you have more trouble falling asleep than you usually do? 9) How often did that happen? 10) Did you have a lot more trouble concentrating than usual? 11) At these times, people sometimes feel down on themselves, no good, or worthless. Did you feel this way? 12) Did you think a lot about death - either your own, someone else's, or death in general?	
Mastery	The extent to which life's events are understood to be controllable by the individual	Ability to control what happens in one's life.	1) You have little control over the things that happen to you 2) There is really no way you can solve some of the	Scores for each individual item were summed (Scores for #6 & #7 were reversed). Possible range is from 0 'no mastery' to 28 'complete mastery'.

			problems you have. 3) There is little you can do to change many of the important things in your life. 4) You often feel helpless in dealing with problems of life. 5) Sometimes you feel that you are being pushed around in life. 6) What happens to you in the future mostly depends on you. 7) You can do just about anything you really set your mind to.	
Self-esteem	The extent to which a person feel good about who they are.	Positive feelings towards one's self	1) You feel that you have a number of good qualities 2) You feel that you're a person of worth at least equal to others. 3) You are able to do things as well as most other people. 4) You take a positive attitude toward yourself. 5) On the whole you are satisfied with yourself. 6) All in all, you're	Scores were summed over each item with a total possible score of 24 (Score for question #6 were reversed)

			inclined to feel you're a failure.	
Emotion	Ability to enjoy life.	Level of emotion experienced on most days.	1) Would you describe yourself/... as being *usually:* So unhappy that life is not worthwhile Unhappy with little interest in life Somewhat unhappy Somewhat happy Happy and interested in life	0 So unhappy that life is not worthwhile 1 Unhappy with little interest in life 2 Somewhat unhappy 3 Somewhat happy 4 Happy and interested in life
Social Activity	Belief in a higher power.	Religious Attendence	Other than on special occasions (such as weddings, funerals or baptisms), how often did you attend religious services or religious meetings in the past 12 months?	0 Not at all 1 At least once a year 2 At least 3 to 4 times a year 3 At least once a month 4 Weekly
Cognition	Ability to think clearly to be complete daily activities	Cognition entails the ability to be reasonable, to have good judgment, and to correctly perceive the world around you	1) How would you describe your/his/her *usual* ability to remember things? 2) How would you describe your/his/her *usual* ability to think and solve day to day problems?	0 Very forgetful/unable to remember 1 Difficulty thinking 2 Somewhat forgetful 3 No memory problems 4 No cognitive problems
Sense of Coherence	Ability to understand life		1) How often do you have	Scores where summed to create

as manageable, controllable, and comprehensible

the feeling that you don't really care about what goes on around you?

2) How often in the past were you surprised by the behaviour of people whom you thought you knew well?
3) How often have people you counted on disappointed you?
4) How often do you have the feeling you're being treated unfairly?
5) How often do you have the feeling you are in an unfamiliar situation and don't know what to do?
6) How often do you have very mixed-up feelings and ideas?
7) How often do you have feelings inside that you would rather not feel?
8) Many people -- even those with a strong character -- sometimes feel like sad sacks (losers) in certain situations. How often

an index score. Higher index score represents greater sense of coherence.

			have you felt this way in the past?	
			9) How often do you have the feeling that there's little meaning in the things you do in your daily life?	
			10) How often do you have feelings that you're not sure you can keep under control?	
			11) Until now your life has had no clear goals or purpose or has it had very clear goals and purpose?	
			12) When something happens, you generally find that you overestimate or underestimate its importance or you see things in the right proportion?	
			13) Is doing the things you do every day a source of great pleasure and satisfaction or a source of pain and boredom?	
Education	Highest level of education	What is the highest level of		Categorical ranging from 1 'no

	achieved.	education that ... have/has attained?	schooling' to 12 'masters/degree in medicine/doctorate/'
Income	Adequacy of income.	What is your best estimate of the total income before taxes and deductions of all household members from all sources in the past 12 months?	0 Lowest Income 1 Lower middle income 2 Middle income 3 Upper Middle income 4 Highest Income
Social Support	Adequacy of social support	1) Do you have someone you can confide in, or talk to about your private feelings or concerns? 2) Do you have someone you can really count on to help you out in a crisis situation? 3) Do you have someone you can really count on to give you advice when you are making important personal decisions? 4) Do you have someone that makes you feel loved and cared for?	Sum of questions #1, 2, 3, & 4. 0 would represent no social support, and 4 would represent full social support.

Appendix 3-B: Comparison of Theory and NPHS

	Theory	NPHS	Variable Name
Physical			
	Mobility	Mobility	DVMOBFG
	Agility	Dexterity	DVDEXFGF
	Pain	Pain & Discomfort	DVPAAF94
	Loss of Energy	Activity	DVDAFQ94
	Hearing Loss	Hearing	DVHEAFG
	Vision Loss	Vision	DVISFG
	Not mentioned	Nutrition	B_Q01
Psychological			
	Depression	Depression	DVSFS94
	Emotional Disturbance	Emotion Attribute	DVEMGF94
	Psychiatric Disorders	Not Available	
	↓ sense of self-worth	Self-esteem	DVESTI94
	Not Mentioned	Mastery	DVMASI94
Cognitive			
	↓Intellectual Functioning	Sense of Coherence	DVSCI94
	Memory Loss	Cognition	DVCOGFG
	Not Mentioned	Level of Education	DVEDC294
Spiritual			
	Loss of Hope	Not Available	
	↓ altruistic behavior	Not Available	
Financial			
	↓ funds to live on	Level of Income	DVINC594
	↓ material possessions	Not available	
	↓material resources	Not Available	
Interpersonal			
	Availability of family, friends, acquaintances	Perceived social support	DVSSI194
	Social Activities	Religious Attendance	SUP-Q2A
Living Situation			
	Home Hazards	Not Available	
	Dangerous Neighborhood	Not Available	
	Distance from Stores	Not Available	
Legal Factors			
	License to Drive	Not Available	
	Control over personal finances	Not Available	